Denitrification of Tile Water Using Woodchip Bioreactors
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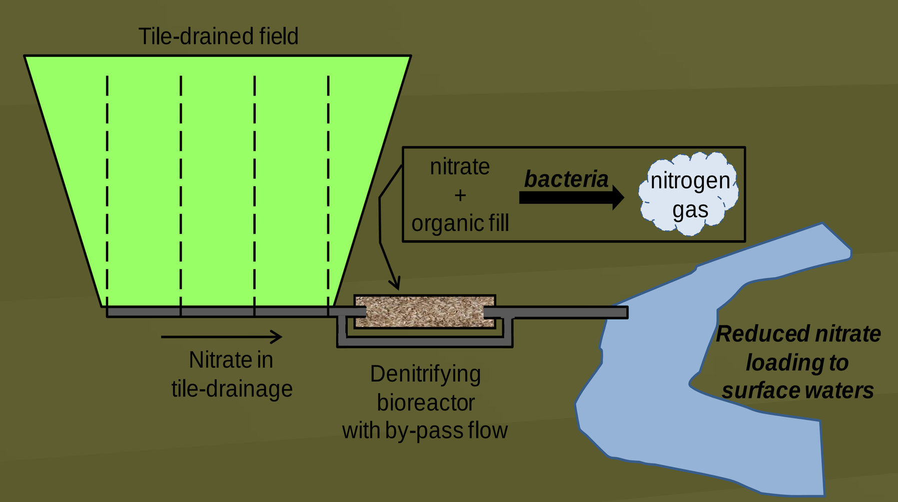
Background

Over 100 years ago, much of Northern Iowa consisted of wetlands that could not be farmed. As a result, tile drainage systems were installed to remove excess water from the fields. Over the years, nitrate, which is a form of nitrogen that is easily moved out of the fields into the drainage water, has increased due in part to fertilizer usage. This increased volume of nitrate can have a detrimental effect on plant and animal life in the streams and rivers. Denitrification, or a reduction in the nitrates, occurs naturally in the soil over time. However, because water drains at a quick rate, maximizing denitrification is difficult. Denitrification occurs when 1) there is bacteria present, 2) the bacteria have a food source (carbon) 3) the conditions are anaerobic, and 4) there is time for the bacteria to colonize. To help reduce nitrates in the drainage water, scientists have been experimenting with woodchip bioreactors.

Woodchip Bioreactors

A woodchip bioreactor is installed at the edge of an agricultural field in order to help reduce the nitrates in the water. To make a woodchip bioreactor, a trench is dug at the edge of an agricultural field and is filled with woodchips. The woodchips are then covered with soil. The water from the tile drainage enters in bioreactor and is retained for eight hours (retention time) in order to give the bacteria enough time to "eat" the carbon in the woodchips and "breathe" the nitrogen in the drainage water. The cleaned water is then drained out of the bioreactor and into the streams and rivers.



Objectives

The overall goal of this research was to determine the conditions in which field bioreactors will maximize denitrification.

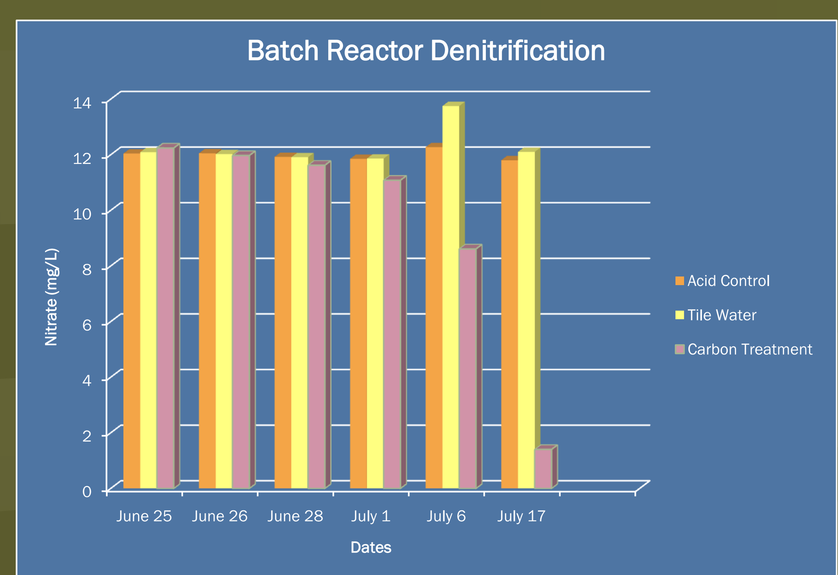
The objectives of our experiments were to simulate full scale woodchip bioreactors in the lab and to determine where the bacteria were coming from. We did this by designing two experiments to conduct in the lab.

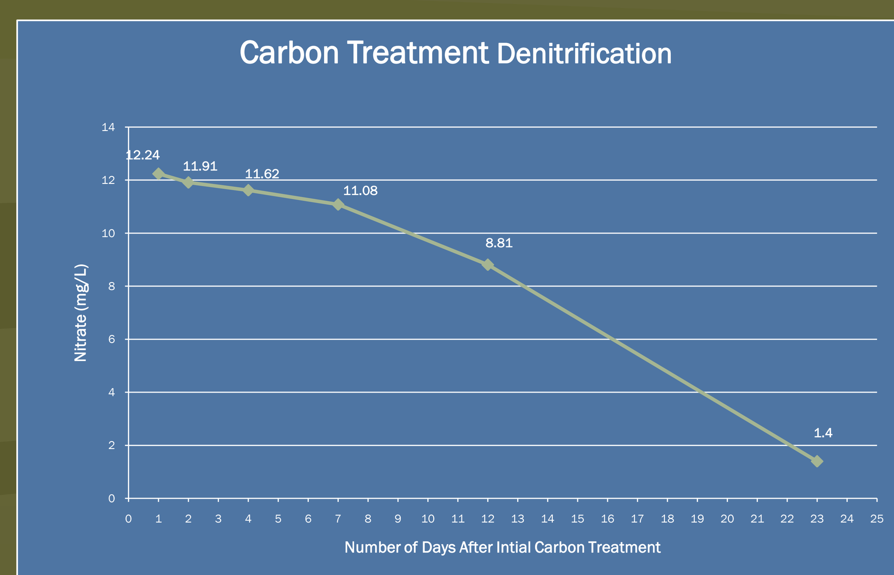
Experiment #1:

Batch Reactors: Our objective was to determine if the tile drainage water contained organisms capable of denitrification.

Materials/Methods:
For this experiment, 32 mL test tubes were used for the batch reactors. For each batch, six test tubes were used for a total of six batches (33 total test tubes). In each batch, one tube was filled with tile water and as a control, acid was added to kill all existing bacteria. Two tubes were filled with tile water, and three tubes were filled with tile water and a carbon source (dextrose). Because the environment needed to be anaerobic, all tubes had no headspace. The tubes were placed on a mechanical shaker and removed after a predetermined period of time, one batch at a time. After removing each batch, acid was added to each test tube to preserve the solution, and they were stored in the refrigerator until the nitrate levels could be analyzed.

Results: 1) There was not enough carbon in the tile water to support denitrification. 2) In the batch reactor, it took an estimated ten days for the carbon-supported tubes to reduce the nitrate levels to the EPA's requirement of 10 m/L.



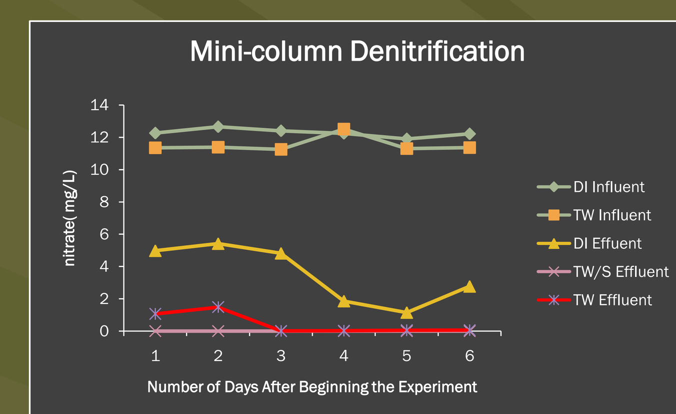


Experiment #2:

Mini-column Reactors: Our objective was to 1) simulate full-scale woodchip bioreactors in the lab, 2) determine how bioreactors vary with and without the addition of soil, and 3) determine if there is bacteria in the woodchips.

Methods/Materials:
This experiment was very similar to the batch experiment; however, we used woodchips for the carbon source instead of dextrose. For this experiment, 5 - one liter bottles (mini-columns) were used . Pumps were used to allow water to flow through in a similar manner to the actual woodchip bioreactors. All bottles were first packed with woodchips. Three bottles were filled with tile water, one bottle was filled with de-ionized water (the negative control), and one bottle was filled with tile water with a small amount of soil (the positive control). The pumps were set so that the retention time was eight hours. Daily samples of the influent water was collected. In addition, a composite sample and a grab sample (50 mL) of each bottle was collected daily.

Results: After beginning the experiment, denitrification occurred in the tile water/soil composite sample and the tile water composite sample after day two and dropped below one mg/L on day three. Denitrification in the DI composite sample also occurred after day two, but at a slower rate and never dropped below one mg/L.



Conclusions

1) Based on the batch reactor experiment, we can conclude that there is not enough carbon in the tile water to support denitrification. 2) Based on the mini-column experiment, we can conclude that the wood chips have micro organisms that support denitrifcation. 3) Since the results were similar in the tile water/soil composite sample and the tile water composite sample, we can conclude that the soil had no effect on the denitrification rate.

Acknowledgements

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